LOCATION ACCURACY

MOVING PLATFORMS

Question:

How does PTT movement affect location accuracy?

Argos states that the DCLS can track moving objects. I know my animal (raptor) can travel upwards of 30 meters/second.

I recall an 'internal' Argos parameter assigned to my PTTs that categorized them as 'moving platforms', with a rate of 1 meter/second.

What are the consequences if this parameter is grossly incorrect? Will I still acquire locations if the PTT is moving 30 meters/second? Can I query this parameter, and if it's incorrect, how can I change it to a more realistic value?

The effect of PTT movement on location accuracy is likely dependent on relative geometries between the satellite orbits and the PTT vectors.

Could you arrange for an Argos specialist to explain how PTT movement, at different rates and directions relative to the satellite ground-track, would be expected to affect location accuracy? I presume that the effect of PTT movement, as functions of rate and direction relative to the satellite ground-track, could be theoretically modeled. This type of modeling would render an excellent manuscript for Argos to publish, and it would save animal trackers a tremendous amount of time and money driving PTTs around on the tops of cars to empirically estimate the same solution.

Related Question: Assume I receive 8 messages from a PTT while it was moving upwards of 20 meters/second. Call these messages, chronologically, A, B, C, D, E, F, G, and H. Consider a data processing strategy that utilized subsets of the messages in an attempt to detect if the PTT was in fact moving, and if so, the general direction of movement. For example:

Using messages A, B, C, and D -> calculate location A'
Using messages B, C, D, and E -> calculate location B'
Using messages C, D, E, and F -> calculate location C'
Using messages D, E, F, and G -> calculate location D'

Assess the spatial dispersion of A', B', C' and D' and use the information to either reject the hypothesis that the PTT was moving, or accept the hypothesis and infer the general direction and speed. Is such a data processing strategy feasible? Has it already been attempted?

Answer:

A. The user can identify, in their Argos Technical File, what the maximum expected velocity is for their platform. This parameter can be modified by the user at any time by contacting the User Office.

This maximum velocity is used to validate the locations. The magnitude of the velocity assigned to PTT in the Argos file can have a significant impact in Argos location processing if it is grossly incorrect:

1) When the assigned value (maximum velocity of the PTT) is small (1 meter/second for example), the Argos location software does not make any attempt to take into account the velocity of the PTT.
2) When the value is too small and is grossly incorrect however, the displacement of the PTT between the current computed position and the previous one can be considered as improbable and the result not delivered to the user.

B. When computing a location, the Argos location software first assumes that the PTT was stationary during the satellite pass. The Doppler technique is not accurate enough to evaluate PTT velocity on one satellite pass (10 minutes on average).

[SEE ALSO OUR REPONSE BELOW TO YOUR DATA PROCESSING STRATEGY TO DETECT WHETHER OR OT THE PTT WAS MOVING]

By applying some strict criteria (for example by requiring at least 4 messages), the Argos location software tries to calculate a location. When the previous location is not older than 3.5 hours, the location software estimates the speed of the PTT using this calculated candidate location and the previous one. The software then calculates another location taking into account this estimated speed of the PTT and, if results are improved, using the assumption that the PTT has moved at a uniform speed since the previous location, the new location result is kept. In this case, 2 more parameters are estimated: Velocity in latitude and velocity in longitude.

When these criteria are not applied, the PTT location delivered to the user is more or less wrong and the magnitude of the error is proportional to the speed of the PTT. We can estimate the resulting error by the following formula:

1) <u>Condition A</u> – If the PTT is moving parallel to the satellite ground track, the error is maximum : around 200 meters X velocity(in Km/h)
[example if the PTT is moving at a speed of 20 km/h during the satellite pass ; the error made on the location is 4 km.]

2) <u>Condition B</u> – If the PTT is moving perpendicular to the satellite ground track, the error is approximately 100 meters X velocity (in Km/h)

In both cases the error is mostly cross track.

Below is an example of a PTT moving at 10 m/s or 36 km/h parallel to the satellite ground track:

Distance to the ground track (or CTA) in degrees

C. To summarize, here is how the Argos location process is working today when it tries to take into account the velocity of the PTT:

1) The process first checks if the PTT has a rapid moving/maximum velocity parameter supplied by the user to the user Office,
2) Then the process computes a location assuming the PTT was stationary,
3) Then the process estimates the mean velocity (in latitude and longitude) since the last location,
4) If the magnitude of the velocity is significant enough, it computes the location again, using the values estimated in step 3 as initial values for the velocity,
5) If the result of the least squares processing (the residual) is smaller than the residual computed without taking this velocity into account, it

validates this new location. Otherwise, it discards the new location and keeps the previous one.

Of course, this method supposes that the PTT has moved at a uniform speed (and in the same direction) since the last location. Oviously, this assumption can be true only for short time intervals between successive locations. Furthermore, it does not take into account probable erratic movements of the PTT during that time. This method is well adapted to vessel routes.

Therefore, we are finalizing now, a new location method named “multi-pass location method” that will allow locations to be calculated using messages coming from satellite passes that are very close in time over the PTT. We expect that in this case, direction and speed will be estimable if the number of messages is sufficient.

This new method will be implemented with the next Argos processing software (late 2005)

See also on the web site of CLS : Argos general – FAQ ARGOS LOCATION
[http://www.cls.fr/html/argos/general/faq_fr.html]

<u>RESPONSE TO YOUR DATA PROCESSING STRATEGY TO DETECT WHETHER OR NOT THE PTT WAS MOVING :</u>

1) Your suggestion supposes that many messages were collected during that satellite overpass: unfortunately the average number of messages collected during a satellite pass is rarely equal to or greater than 8 (especially for animal tracking)

2) You have understood that the problem is at 2 levels
    a. Is the PTT moving during that satellite overpass?
    b. If yes, in which direction and speed?

However, we do not apply the method you suggest for the following reasons:

Doppler measurements are not accurate enough to determine whether the spatial dispersion of positions is the consequence of an actual PTT displacement, a consequence of the oscillator drift (*) or the result of the uncertainty in where the PTT really is. Furthermore, Doppler measurements need to be well distributed all along the Doppler curve of the satellite pass to obtain an accurate location. If a computation is made using only the Doppler measurements belonging to the beginning of the Doppler curve and another computation is made using the last Doppler measurements, this will lead both to bad results and to an erroneous interpretation of the dispersion of the positions.

(*) Speed of a PTT and oscillator drift have the same Doppler signature.

DATA DISTRIBUTION CONTENT

DIAG SATELLITE ID

Question:

For over 10 years, requests have been made by myself and other users asking Service Argos to include the Satellite ID (eg. H, J, K, L, M, etc.) in the DIAG data format.

The satellite ID parameter is essential for precisely merging (one-to-one) the DISPOSE file overpasses with the DIAG overpasses. In polar regions, and especially under multi-satellite service, numerous overpasses from more than one satellite are collected in close temporal proximity. This causes a purely chronological strategy of matching the DIAG and DISPOSE overpasses to become ambiguous in many instances. If satellite ID were included in the DIAG output format, matching DIAG overpasses with DISPOSE overpasses would be explicit.

Answer:

The DIAG file was designed to contain a single record per satellite pass: "the best record". That means, the one corresponding to the location having the highest quality index and the most "significant" message received during the satellite pass which is the message with the best compression index (same message as in the Telex file). As in the Telex file, the DIAG file format does not include the satellite Identification.

Although there has been an official request for action on this issue by SAI, CLS has not addressed it for 2 principal reasons:

1) It is always difficult to force users to modify their acquisition software to match format evolution,
2) The new distribution interface that will be operational in the second quarter of 2003, will allow users to define their own output format and in particular to select the type of data (from a list) they want to get back. Satellite ID is one of then

---

SIGNAL STRENGTH

Question:

Reporting the best signal strength received during an overpass in the DIAG output is marginally useful for animal trackers. Because signal strength is a function of the distance between the satellite and PTT, this parameter can only be interpreted by analyses of large data volumes in a general attempt to 'see through' the confounding effect of satellite-PTT distance. Conclusions are generally unsatisfactory.

One very good Argos improvement would be to include the distance (km) between the satellite and PTT at the time that the message with the best signal strength was received. This parameter could be included in the DIAG format, and would essentially be 'paired' with the existing 'best signal strength' parameter.

Alternatively, the most informative and most useful improvement would be to include both signal strength and satellite-PTT distance for EVERY received message in the DISPOSE format. This information could be used in several capacities to better understand PTT performance in different habitats and under different regional atmospheric conditions.

Answer:

The information "best signal strength received during a satellite overpass" given in the DIAG output primarily characterizes the receiver (on the satellite) functioning. This information indicates whether the number of messages received during the overpass is consistent or not with the signal strength. For example, it is common to receive only a few messages if the best signal strength is weak.

Keep in mind that signal strength is a function not only of the distance between the satellite and PTT at the time at which the message is received, but it is also the result of the antenna (on the satellite) pattern efficiency. To first order the antenna pattern compensates for the space losses: 10 dB from 5 to 90 degrees elevation angle (2500 km to 850 km).

Also, keep in mind that the satellite - PTT distance can be computed only if a location is determined for the PTT.

As with the previous DIAG satellite ID question we are always reluctant to make changes in the (data distribution) software that will require users to modify their acquisition software. Ideally, as with the DIAG satellite ID question it would be nice to have the signal strength/satellite-PTT distance parameters available for selection by the users for their output format in the new web distribution interface. Unfortunately, the current Argos processing system does not allow for this to be done. No matter what, though, it would not be possible to make the calculation for "....EVERY received message in the DISPOSE format" as is asked, because the DISPOSE file does not include every message that was received. It includes only messages that are not identical (for instance, if 3 consecutive identical messages were received, only the last one is stored in DISPOSE, with a compression index of 3).

This can be discussed further at the Argos Symposium but the recommended approach is to include such a requirement in the next phase of the Argos 2001 project which is scheduled to begin in the Fall of 2003.

DATA PROCESSING

REAL-TIME DATA VS. TAPE PLAYBACK DATA

Question:

The vast majority of animals we track are located within the Gilmore Creek station mask. As NOAA commands the onboard satellite tape recorders, parts of a satellite overpass may be collected in real-time, while other parts may become available only through tape playback on subsequent passes over NOAA ground stations. As I understand from previous discussions with Argos specialists, data collection within a NOAA station mask can cause a PTT's message-data for a given overpass to be disseminated to Service Argos at different times. Essentially, overpass data from a single satellite pass can become 'split' into different data-stream fragments.

In the mid- and late-1980s, we commonly received data from Argos that clearly represented what we termed 'split overpasses'. That is: two Argos overpass entries from the same PTT with the same satellite ID, and with very close temporal proximity. Obviously, the data for these 'two Argos overpasses' really represented messages from a SINGLE satellite overpass.

Since the early 1990s, we rarely detect (visually) any presence of 'split overpasses' in our Argos data.

However, in a cross-tabulation of 63,572 DISPOSE file overpasses collected during 1995-2002, 3.35% of the passes were reported to have 4 or more messages, but the Argos Location Class was reported as an "A" or "B". How is this possible, since "A" and "B" locations are defined to be locations derived from "3" and "2" messages, respectively? Furthermore, the frequency (%) of overpasses with 4 or more messages, and reported with locations classed as "A" or "B", showed an increasing trend over the years 1995-2002 [1.13%, 0.56%, 0.47%, 0.97%, 1.24%, 3.89%, 4.18%, and 7.97%, respectively].

If possible, please have an Argos specialist describe <u>EXACTLY</u> how real-time vs. playback data are treated in the data processing sequence:

- ***What happens if 3 messages are received for a given overpass in real-time, and additional messages are received by Argos later in the day from tape playback?***
- ***Are the first 3 messages used to 'quickly' derive a location for the user?***
- ***Are <u>ALL</u> messages <u>later</u> reassembled into a single overpass, and used to derive the most robust and accurate location?***

- ***Could the Argos treatment of real-time vs. playback messages be causing the differences we observe between data receive through ADS vs. the data we receive in our monthly CD-ROM databanks?***

Answer:

When a satellite is flying over a global ground station (Gilmore creek or Wallops for instance), The station usually commands:

1) The onboard satellite tape recorder to switch from the current tape recorder to a new one,
2) To download data received during the previous orbit

while messages received by the satellite during the satellite overpass are also collected in real-time (via another channel).

Suppose a PTT, close to the ground station, is transmitting during that time.

First messages from the PTT are recorded on the previous tape recorder (till tape recorder switch over) and last messages on the new one. In parallel, a part of them are collected in real time. Conclusion, messages transmitted by the PTT during this satellite pass, are present in 3 data-streams which will be received and processed in the Argos processing centre at different times. The real time data-stream will come in first.

The Argos data collection processing principle is to process data as soon as they come in. If the messages from a single pass are split into different data-streams, the DISPOSE file, corresponding to the satellite pass, will contain first only PTT messages collected from the real time data-stream and, then, when other data-streams (called global data-streams) including messages from the PTT (corresponding to the same satellite pass) will come in, the Argos processing can rebuild the satellite pass. .

It is important to remember that the Argos location processing principle is to process data as soon as they come in.

If The User Selects Service+ Locations:

If, for a given PTT, **SERVICE** + location is required by the user: a location calculation is performed as soon as 2 messages transmitted by the PTT are collected. Dopplers are stored 12 hours, consequently, if during that time, new messages (from the same satellite pass) come in, the location process performs a new location calculation using both previous Dopplers and the additional ones. The new location will replace the previous one whenever it is better.

If the Users Selects Standard Locations:

If, for a given PTT, only **standard locations** are required by the user: a location calculation is performed only when at least 4 messages transmitted by the PTT are collected. Dopplers are stored 12 hours whenever the location was computed with less than 5 Dopplers. In that case, if new messages (from the same satellite pass) come in, the location process performs a new location calculation using both previous Dopplers and the additional ones. The new location will replace the previous one whenever it is better.

It is not unusual to observe differences between data received through ADS and data received in monthly CD-ROM databank, especially if the ADS process selected by the user is triggered by the arrival of new data.